Allergenic Hazards

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Chapter x: Allergenic Hazards

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Introduction:

Food Allergy is one of the most commonly encounter health problem worldwide. It has been estimated that more than 20000 individuals are suffering from this condition (1). The etiologic agents of this clinical condition are known as allergens which simple are proteins that are capable of producing an abnormal immune response in sensitive segments of the population. In principle Allergic reactions to food usually involve IgE antibodies. Symptoms of an allergic reaction range from mild conditions like skin rash and slight itching of the mouth, to migraine headaches, to a life threatening condition known in the medical practice as anaphylactic shock which ultimately leads to death. Several factors are involved in determining the type and severity of an allergic response including dosage, route of administration, frequency of exposure, and most importantly the genetic predisposition.

In general, there is no ultimate cure for food allergies and the only successful method for susceptible individuals is to manage food allergy through avoiding the specific allergen however, alleviating the symptoms are usually achieved by using immunosuppressive drugs. Accordingly, accurate information (e.g. ingredient list) on food labels to manage food allergy are of at most importance. Inaccurate, undeclared or hidden allergens on food labels can pose a significant health hazard to susceptible individuals. This ultimately lead to the development of international strategies and plans like ensuring the strict adherence to good manufacturing practices (GMP), Hazard Analysis Critical Control Points (HACCP), and allergen prevention plans which has significantly reduced the likelihood of cross contamination of the allergen to food product in its finished form.

Part I: Basics of Food allergy and food intolerance

I.I what is food allergy?

Food Allergy is simply defined as the development of certain specific clinical symptoms after ingesting food ingredients. General mild symptoms including but not restricted to skin rashes (hives), itching and swelling of lips, face and tongue shortening of breath, nausea, lightheadedness and runny nose typically appear after minutes to couple of hours after the exposure (2). The immune system of the human body triggers a response against a protein in the food leading to the development of certain types of Immunoglobulin known as IgE which will activate allergy related White blood cells called Mast cells. The activated mast cells produce histamine and other chemical agents which will lead to physiological changes that appear on the exposed individuals.

It is important to differentiate between food allergy and food intolerance because the management and treatment regimens vary. Food intolerance is an abnormal physiological response to a specific food which appears mostly as cramps, diarrhoea and bloating (3). Food intolerance is not a life threatening condition and is usually managed by avoiding the exposure to the causative food type and does not need immunosuppressive therapies. Neither mast cells nor IgE are involved in food intolerance. The best typical example of food intolerance is the intolerance to dairy products which is known as lactose intolerance. This is one of the most common food intolerances worldwide which occurs in people who lack an enzyme called lactase, which is needed to digest sugar milk lactose (4).

In the developed world, about 4% to 8% of people have food allergy (5). Recently, the frequency of food allergy has increased particularly among children compared to adults with higher incidence among males. It is important to note that food allergy varies in frequencies or severity among the different geographical communities in addition to ethnic groups where genetic factors are believed to be responsible for this phenomenon (6). Potential risk factors for food allergy usually include vitamin D insufficiency, unhealthful dietary fat, obesity, increased hygiene, and the timing of exposure to foods.

I.II. Pathophysiology

Food allergy is developed as a natural reaction of the immune system to the allergen, which is a protein in the food that is considered abnormal by the immune system in the susceptible individuals. Generally, workers of the medical practice classify food allergies into two classes according to the mechanism of the allergic response (7).

Class I food allergy is known as the classical form of food allergy which relays on the development of antibodies of the class IgE to the food allergen. This class is the most common type, and typically occurs shortly after eating and may ultimately develop to a life threatening condition known as anaphylaxis which leads to death (8). When immune cells recognize the allergenic protein, IgE antibodies are produced in a similar fashion to the immune system's reaction against foreign pathogens. The IgE antibodies identify the allergenic proteins as harmful and initiate the allergic reaction. IgE antibodies bind to a receptor on the surface of especially immune cells called mast cells which contain histamine and other inflammatory mediators in their cytoplasm. When the allergen binds to the IgE on the surface of the sensitized mast cells, histamine is produced leading to increase in the diameter of blood vessels (vasodilatation) and tightening of wind pipe (bronchoconstriction) exhibiting the principle manifestations and signs of hypersensitivity.

Class II food allergy usually is less common and less severe that class I. In this class, the symptoms usually develop late and after 12 hours of exposure. The mechanism of this class of food allergy is not IgE antibodies dependent and it involves improper activation of T cell lymphocytes in the stomach mucosa (9). Here, the immune system can harm the human gut gradually leading to symptoms related to the gastrointestinal system. It is noteworthy to diagnose this class of food allergy because if exposed individuals are not cured, the condition might develop to chronic phase and end with damage of certain parts of the gut leading to maldigestion and malabsorption.

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The pathological effects of food allergy usually exhibit two phases. In the acute phase, the immunological reaction occurs immediately after exposure to an allergen and depending on the nature and amount of allergen, it can either subside or progress into a

"late-phase reaction" which can substantially prolong the symptoms of a response, and result in tissue damage. Proteins constitutes the chemical nature of almost all allergens, since they possess unique properties that allow them to become allergens, such as stabilizing forces in their tertiary and quaternary structures making these proteins resistant to degradation during digestion. Many theoretically allergenic proteins cannot survive the destructive environment of the digestive tract, thus do not trigger hypersensitive reactions (10).

I. III Food Allergens

Allergens are chemical agents that when entered to human body triggers an allergic reaction by the immune system of the exposed individuals. In case of food allergy, numerous types of allergens are present in different types of food ingredients. Food allergens might be present in herbal food and in animal products as well. Food allergy can also be developed to chemically modified product that is added to food product like additives, preservatives and some flavors (11, 12).

The international survey programs have list the most common food allergens for which 95% of food allergy cases are attributed to. These allergens include (arranged according to the highest incidence):

- Peanuts and tree nuts (almonds, Brazil nuts, cashews, hazelnuts, macadamia nuts, pecans, pine nuts, pistachio nuts, and walnuts)
- Soy
- Seafood (fish, crustaceans, and shellfish)
- Sesame seeds
- Milk and Eggs
- Wheat
- Sulphites
- Mustard
- Banana

Most of the individuals do not know exactly what food allergen they are susceptible for and thus making inaccurate generalization about their food which might cause

malnutrition. It is important to note that cross reactivity is a common challenge in food allergies (13). Simply, if a person is allergic to shrimp, he or she may be allergic to other types of shellfish, such as crab or crayfish. This happens when proteins in one food are similar to the proteins in another food because IgE antibodies can share similar specificities to chemically similar allergens typically observed in cases of proteins. The case is much complicated in some people who have allergies to pollens, such as ragweed and grasses. Proteins in the pollens are like the proteins in some fruits and vegetables. This condition is called oral allergy syndrome which is reported in approximately 60% of cases of food allergies in adults (14).

I. IV. Diagnosis

Diagnosis of food allergies is one of the most important tools required for proper management and treatment of such conditions. It is actually an integral task in the preventive measures adopted by health agencies worldwide.

The first approach for the diagnosis of food allergies relays on the medical history of the exposed individual. Actually, the full the description of the medical history of the exposed individual, the faster and the accurate the diagnosis will be.

The diagnostic tools used depends on either the development of typical symptoms after injecting a suspected allergen into the skin in the so called skin-prick tests or by the measurement of total IgE antibodies and their specificities to a panel of suspected allergens in the laboratories (in vitro).

In the skin test, the procedure involves the introduction of a tiny board with protruding needles containing the allergens of interest directly beneath the skin followed by monitoring the development of allergy related symptoms. If a hive appears within minutes, the person is considered positive for the allergy. The drawbacks of this test include its insensitivity in cases of allergic reactions caused by antibodies other than IgE and the risk of the invasive procedure (15,16). These factors collectively make the use of this test restricted to confirm an allergy in light of a patient's history of reactions to a particular food.

The most sensitive and specific testing for food allergies is the blood testing of the total IgE concentration (Antibody titier) and their specificity to certain allergens. The most widely used template for IgE is known as radioallergosorbent testing (RAST). The score taken from the RAST when compared to predictive values can predict the likelihood of the tested allergen to be a cause of allergy. One advantage of this test is that it can test a panel of allergens at one time (17). The disadvantage of this test is similar to skin test in which the non IgE mediated food allergies cannot be detected.

Recent efforts have been widely exerted to test for allergens other than those caused by IgE. Food challenges test is a recently developed method to achieve this goal. In this test, the allergen is given to the person in the form of a pill, so the person can ingest the allergen directly and subsequently, the person is closely monitored for the development of signs and symptoms. The risk of developing anaphylaxis is one of the major drawbacks of this approach hence limiting the test to be performed in the hospital under careful watch (18).

As in most clinical conditions, differential diagnosis is required and important especially in cases of lactose intolerance and celiac disease which is an autoimmune disorder triggered by gluten proteins such as gliadin (present in wheat, rye, and barley). In addition, Irritable bowel syndrome should be first excluded particularly in cases of gastric symptoms.

In conclusion, the diagnosis of food allergies is not a simple task and has many drawbacks particularly when we consider the cost of the tests and the need for patient's compliance to the test procedures.

I. V Management and treatment

Management of food allergies is a central part of most health agencies worldwide. Not only, the preventive measures contributed to decrease the incidence of food allergies and exposure to food allergens, but also they improved individual health and reduces the cost of treatment of such disorders.

Among the early preventive measures of food allergies is breastfeeding for more than four months which according to several studies is a successful approach in preventing atopic dermatitis, cow's milk allergy, and wheezing in early childhood. In addition, early exposure to potential allergens may be protective especially in cases of allergy to eggs and peanuts (19).

Allergen free strict diet is one of the best approaches in avoiding food allergies. The effectiveness of this approach depends on the medical history and the proper diagnosis of the cause of the allergy. However, since it is difficult to determine the amount of allergenic food required to elicit a reaction, complete avoidance should be attempted. Moreover, hypersensitivity can be triggered by exposures to food allergens through indirect ways like skin contact, inhalation, kissing, blood transfusions and cosmetics (18).

Treatment of symptoms related to food allergies is important particularly in children and elderly to prevent the development of anaphylaxis. Different drugs are commonly used depending on the severity of reactions. In cases of anaphylaxis, epinephrine (adrenaline hormone) must be promptly used to reverse the situation and alleviating the symptoms by improving blood circulation through tightening of blood vessels and increasing heart rate. The person should then be transported to the emergency room, where additional treatment can be given and after complete check of the patient to ensure no organ damage occurs (20).

Administration of antihistamines and steroids is the first line of treatment of food allergies (19). Antihistamines usually alleviate the early symptoms of food allergies by blocking the action of histamine, which causes blood vessels to dilate and increasing itchiness by acting on sensory nerve terminals. The most common antihistamine given for food allergies is diphenhydramine. Steroids are used to suppress the immune system cells that are attacked by the chemicals released during an allergic reaction. Steroids are usually

administered as nasal spray or taken orally, and in emergencies, through injection, by which every part of the body can be reached and treated.

II. Regulatory aspects of food allergenic hazards

II.I Risk estimation and Risk assessments for food allergens

One of the essential tasks of health and food agencies is to evaluate and assess the risk of food allergens in order to improve quality of life of human beings. Allergen risk assessment programs aim to determine the risks due to unintentional presence of allergens which can help in making the decision of labelling or restriction of a food ingredient is taken.

Risk assessment of food allergens must cover several points including the chance of allergenic hazard get into contact with food products, the amount of the allergenic food generally needed to provoke a reaction in allergic people, the frequencies and severity of adverse reactions and if increase susceptibility of subgroups or geographical region to certain allergens (21).

Practically speaking, risk assessment with the current knowledge and tools is not optimal. Several challenges encounter proper risk evaluation of allergens specifically the allergen thresholds (lower limits under which food allergens will not cause any symptoms). In addition to, the amount of food allergen that may trigger allergic reactions visible for others range from a tenth of milligram in rare cases up to grams, and sometimes tens of grams, with considerable variability between individuals as well as between allergens (22). A review conducted since the 1970s reported that the most of food-allergic individuals tested would need to eat more than 500 mg of the offending food to trigger allergic reactions, but a significant minority responded to lower doses.

Recently, scientists and regulatory authorities have started discussions on what is the best way to make statistical evaluations of the individual data taking into consideration the allergenic hazards. To the best of our knowledge, the Australian Food and Grocery Council is the first organization to develop and recommend the use of an allergen risk

assessment tool to harmonise the application of allergen precautionary labelling. This effort concluded that the best measure for decreasing allergenic hazard is to prevent and minimize the cross contact in the premises of food industry (23).

Food allergy awareness is another tool that is increasingly used to decrease the risk of allergenic hazard (24, 25). In the United States, the efforts of Food Allergen Labeling and Consumer Protection Act of 2004 remarkably aided people to be reminded of allergy problems every time they handle a food package, and restaurants have added allergen warnings to menus. In addition, chef training courses in allergen-free cooking and a separate teaching kitchen (26) were conducted by the Culinary Institute of America. Standard protocols about what foods can be brought into the school were also adopted. Lastly, for children with allergies, their quality of life is also affected by actions of their peers. The increased occurrence of bullying including threats or acts of deliberately being touched with foods they need to avoid, increased the contamination of their allergen-free food (27).

II.II Regulation of labelling

Recently, most countries have responded to the risk for food allergens by instituting labeling laws that require food products to clearly inform consumers if their products contain major allergens or byproducts of major allergens. Moreover, customers are compulsory warned by companies when food has been prepared around certain allergens that have been known to cause severe reactions (28). Under the U.S. Food Allergen Labeling and Consumer Protection Act of 2004 (Public Law 108-282), companies are required to disclose on the label whether the product contains any of eight major food allergen, cow's milk, peanuts, eggs, shellfish, fish, tree nuts, soy and wheat, in clear plain language . In addition, all allergens have to clearly be called out in the ingredient statement. Section 112 of the federal law the Food Safety and Modernization Act of 2010 (S510/HR2751, 111th Congress) established voluntary food allergy and anaphylaxis management guidelines for public kindergartens and elementary and secondary schools (29).

In Europe, molluscs, celery, mustard, lupin, sesame and sulfites in addition to the allergens mentioned above must be listed in the ingredient lists if present. The EU Food Information for Consumers Regulation 1169/2011 – requires food businesses to provide allergy information on food sold unpackaged, for example, in catering outlets, deli counters, bakeries and sandwich bars (30). The allergenic ingredients need to be clarified using a typeset that clearly distinguishes it from the rest of the ingredients usually by means of the font, style or background color. In cases of byproducts originated from a single allergenic ingredient, the labelling should make this clear for each ingredient or processing aid concerned as in case of milk in the following products skimmed **milk** powder, whey (**milk**), lactose (**milk**).

In some cases foods are offered to sale to the final consumer or to mass caterers without packaging. In these cases, information about allergenic ingredients is mandatory and must be provided. Similarly if foods are packed on the sales premises at the consumer's request or prepacked for direct sale. In addition, when allergen information is not provided upfront for non-prepacked foods, written or oral formats with clear signposting of the allergen information should be provided to the consumers.

II.III Responsibilities of Food industry

The control of food allergens has become one of the major issues regarding food safety worldwide. As part of the industrial processes, food manufacturers have mandatory established controlled measures and process validation which ensure the avoidance of cross contamination of food allergens (31). Currently, authorities recommend an approach to allergen control based on the HACCP principles that have been so successful in managing other food safety hazards as in case of guidance from the UK-based Institute of Food Science and Technology (IFST). By this approach, the following well controlled strategy was adopted:

- The entire manufacturing process should be analysed in relation to allergen hazards as recommended by HACCP plan.

- Segregation of manufacturing operations especially those involving the allergen-containing food is mandatory in multi-product companies.
- Formulation of foods should be free of all unnecessary major allergens as ingredients when possible.
- All raw materials supplies, storage and handling, production schedules and cleaning procedures should be organized to prevent cross-contamination of products by 'foreign' allergens.
- Proper and Sufficient training should be provided to all personnel.
- Compliance with the relevant labelling legislation.
- Availability of a valid recall system for any product found to contain a major allergen not indicated on the product label (32).

Adherence to GMP procedures is the key stone for the food manufacturers to ensure best practice of avoiding mis-formulation, cross contamination, inadequate cleaning and re-work. Most manufacturers utilize separate equipment for products containing specific allergens, while larger manufacturers set up separate manufacturing facilities for products containing allergens to eliminate the risk of cross contaminating other products.

Allergen control plans have been recently more implemented by each manufacturer. The plans generally focus on identifying and tracking ingredients that contain allergens using an allergen map, dedication of processing equipment to allergenic products and strict control of rework and packaging. Clear validation measures and protocols using sampling and testing for allergen residues on equipment and surfaces are required to ensure effective cleaning and decontamination.

It is noteworthy to mention that undeclared allergens in food remains one of the main reasons for recalling products from the market despite all the advice available and the adoption of the proven HACCP-based approach to controlling allergen contamination. In 2010, over 120 recall incidents related to food allergens were recorded by US FDA, while in the UK in 2011, the Food Standards Agency issued 50 Food Alerts, but no less than 57 Allergy Alerts (33). Accordingly, manufacturers increased their awareness of applying the term "may contain" warnings on many foods. Widespread use of precautionary

labelling also presents problems for allergic consumers, who may find their choice of products severely limited and may be tempted to ignore valid warnings.

II. IV. The problem of genetically modified food

Genetically modified organisms (GMO) which are foods generated by biotechnology and bioengineering methods have been increasingly placed in the markets for consumers. Since reports regarding increasing the incidence of food allergies after the introduction of these products, major concerns are now considered regarding GMOs as being responsible for allergic reaction (34). The major concern is the effect of genetic engineering itself would increase the likelihood that an allergy-provoking food more allergic, meaning that smaller portions would suffice to set off a reaction (35). The best example is seen in case of GMO soybeans which have been significantly identified as a common allergen. This is remarkably illustrated for the fact that soybean proteins known to trigger allergic reactions, there is more variation from strain to strain than between those and the GMO varieties. Nevertheless, National Academy of Sciences report concluded no relationship between consumption of GE foods and the increase in prevalence of food allergies (36).

A second concern of GMOs is the potential of converting a non-allergenic food into allergenic one when genes are transferred from on species to another. The situation was clearly investigated by an attempt to enhance the quality of soybean protein by adding genes from Brazil nuts due to tree nut allergy in human volunteers (36).

Currently, clear criteria need to be met prior to a new GMO food receiving government approval. These include: the risk of the donor species to be allergenic, degree of similarity of the amino acid sequence between the transferred proteins to sequence of known allergenic proteins and the susceptibility of transferred proteins to digestion. Lastly, there are requirements in some countries and recommendations in others that all foods containing GMO ingredients be so labeled, and that there be a post-launch monitoring system to report adverse effects (much there exists in some countries for drug and dietary supplement reporting) (34, 35) According to a 2015 report from the Center for Food Safety, 64 countries require labeling of GMO products in the marketplace (37).

References

1. Sicherer, Scott H. "Epidemiology of food allergy." *Journal of Allergy and Clinical Immunology* 127, no. 3 (2011): 594-602.

2. Sampson, Hugh A. "Update on food allergy." *Journal of Allergy and Clinical Immunology* 113, no. 5 (2004): 805-819.

3. Lomer, M. C. E. "The aetiology, diagnosis, mechanisms and clinical evidence for food intolerance." *Alimentary pharmacology & therapeutics* 41, no. 3 (2015): 262-275.

4. Misselwitz, Benjamin, Daniel Pohl, Heiko Frühauf, Michael Fried, Stephan R. Vavricka, and Mark Fox. "Lactose malabsorption and intolerance: pathogenesis, diagnosis and treatment." *United European gastroenterology journal* 1, no. 3 (2013): 151-159.

5. Gray, Claudia L., and Michael E. Levin. "Epidemiology of food allergy." *Current Allergy & Clinical Immunology* 27, no. 3 (2014): 170-176.

6. Sicherer, Scott H., and Hugh A. Sampson. "Food allergy: epidemiology, pathogenesis, diagnosis, and treatment." *Journal of Allergy and Clinical Immunology* 133, no. 2 (2014): 291-307.

7. Eigenmann, Philippe A., Scott H. Sicherer, and Elizabeth TePas. "Pathogenesis of food allergy." *Acessível em: www. uptodate. com* (2013).

8. Eigenmann, Philippe A., Scott H. Sicherer, Teresa A. Borkowski, Bernard A. Cohen, and Hugh A. Sampson. "Prevalence of IgE-mediated food allergy among children with atopic dermatitis." *Pediatrics* 101, no. 3 (1998): e8-e8.

9. Helm, Ricki M., and A. Wesley Burks. "Mechanisms of food allergy." *Current Opinion in Immunology* 12, no. 6 (2000): 647-653.

10. Mayo Clinic. Causes of Food Allergies. Archived 2010-02-27 at the Wayback Machine. April 2010.

11. Breiteneder, Heimo, and Christian Radauer. "A classification of plant food allergens." *Journal of allergy and clinical immunology* 113, no. 5 (2004): 821-830.

12. Cianferoni, Antonella, and Jonathan M. Spergel. "Food allergy: review, classification and diagnosis." *Allergology International* 58, no. 4 (2009): 457-466.

13. Vieths, Stefan, Stephan Scheurer, and B. A. R. B. A. R. A. BALLMER-WEBER. "Current understanding of cross-reactivity of food allergens and pollen." *Annals of the New York Academy of Sciences* 964, no. 1 (2002): 47-68.

14. Kondo, Yasuto, and Atsuo Urisu. "Oral allergy syndrome." *Allergology International* 58, no. 4 (2009): 485-491.

15. Knight, Adina Kay, and Sami L. Bahna. "Diagnosis of food allergy." *Pediatric annals* 35, no. 10 (2006): 709-714.

16. Bahna, Sami L. "Diagnosis of food allergy." *Annals of Allergy, Asthma & Immunology* 90, no. 6 (2003): 77-80.

17. Sampson, Hugh A., and Deborah G. Ho. "Relationship between food-specific IgE concentrations and the risk of positive food challenges in children and adolescents." *Journal of Allergy and Clinical Immunology* 100, no. 4 (1997): 444-451.

18. Sicherer, Scott H. (2006). *Understanding and Managing Your Child's Food Allergy*. Baltimore: Johns Hopkins University Press.

19. "European Food Allergy and Anaphalaxis Public Declaration". the European Academy of Allergy and Clinical Immunology (EAACI). Archived from the original on 15 December 2013. Retrieved 10 December 2013.

20. Boyce, Joshua A., Amal Assa'ad, A. Wesley Burks, Stacie M. Jones, Hugh A. Sampson, Robert A. Wood, Marshall Plaut et al. "Guidelines for the diagnosis and management of food allergy in the United States: summary of the NIAID-sponsored expert panel report." *Journal of the American Academy of Dermatology* 64, no. 1 (2011): 175-192.

21. Crevel, Rene WR. "Risk Assessment for Food Allergy." *Allergen Management in the Food Industry* (2010): 421-451.

22. Madsen, Charlotte Bernhard, S. Hattersley, J. Buck, S. M. Gendel, G. F. Houben, JO'B. Hourihane, A. Mackie et al. "Approaches to risk assessment in food allergy: report from a workshop ''developing a framework for assessing the risk from allergenic foods''." *Food and Chemical Toxicology* 47, no. 2 (2009): 480-489.

23. Kuiper, Harry A., Gijs A. Kleter, Hub PJM Noteborn, and Esther J. Kok. "Assessment of the food safety issues related to genetically modified foods." *The plant journal* 27, no. 6 (2001): 503-528.

24. Lange L (2014). "Quality of life in the setting of anaphylaxis and food allergy". Allergo J Int. 23 (7): 252–260. doi:10.1007/s40629-014-0029-x. PMC 4479473 Freely accessible. PMID 26120535.

25. Van der Velde JL, Dubois AE, Flokstra-de Blok BM (2013). "Food allergy and quality of life: what have we learned?". Curr Allergy Asthma Rep. 13 (6): 651–61. doi:10.1007/s11882-013-0391-7. PMID 24122150.

26. Culinary Institute of America Allergen-free dining oasis comes to the CIA (2017).

27. Fong AT, Katelaris CH, Wainstein B (2017). "Bullying and quality of life in children and adolescents with food allergy". J Paediatr Child Health. 53 (7): 630–635. doi:10.1111/jpc.13570. PMID 28608485.

28. Allen, Katrina J., Paul J. Turner, Ruby Pawankar, Stephen Taylor, Scott Sicherer, Gideon Lack, Nelson Rosario et al. "Precautionary labelling of foods for allergen content: are we ready for a global framework?." *World Allergy Organization Journal* 7, no. 1 (2014): 10.

29. Strauss, Debra M. "An analysis of the FDA food safety modernization act: protection for consumers and boon for business." (2011).

30. "Food allergen labelling and information requirements under the EU Food Information for Consumers Regulation No. 1169/2011: Technical Guidance" (April 2015).

31. Taylor, Steve L., and Sue L. Hefle. "Allergen control." *Food technology* 59, no. 2 (2005).

32. Knowles, Tim, Richard Moody, and Morven G. McEachern. "European food scares and their impact on EU food policy." *British food journal* 109, no. 1 (2007): 43-67.

33. McGowan, Emily C., and Corinne A. Keet. "Prevalence of self-reported food allergy in the National Health and Nutrition Examination Survey (NHANES) 2007–2010." *The Journal of allergy and clinical immunology* 132, no. 5 (2013).

34 Bawa, A. S., and K. R. Anilakumar. "Genetically modified foods: safety, risks and public concerns—a review." *Journal of food science and technology* 50, no. 6 (2013): 1035-1046.

35. Selb, R., J. M. Wal, F. J. Moreno, M. Lovik, C. Mills, K. Hoffmann-Sommergruber, and A. Fernandez. "Assessment of endogenous allergenicity of genetically modified plants exemplified by soybean–Where do we stand?." *Food and Chemical Toxicology* (2017).

36. Dunn, S. Eliza, John L. Vicini, Kevin C. Glenn, David M. Fleischer, and Matthew J. Greenhawt. "The allergenicity of genetically modified foods from genetically engineered crops: a narrative and systematic review." *Annals of Allergy, Asthma & Immunology* 119, no. 3 (2017): 214-222.

37. International Labeling Laws". Center for Food Safety. http://www.centerforfoodsafety.org/issues/976/ge-food-labeling/international-labeling-laws

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